Strengthening Technical Peer Review at the Army S&T Laboratories

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Chapter 1: Introduction to Peer Review

The assumption underlying the value of peer review is that the quality of work is substantiated or improved through critiques by individuals who are independent, objective, and have specialized knowledge in the subject matter. One of the authors (Dr. Lyons) has had firsthand experience with such reviews. Some time ago, while in the private sector, he was asked to serve on a National Research Council (NRC) ad hoc committee of external, independent experts to review the fire research program at the National Bureau of Standards (NBS). The committee found the programs to be fragmented and deficient in basic research, and made a number of recommendations on how to improve them. (For more on how such a committee operates, see the discussion of the National Institute of Standards and Technology in chapter 3.) The result was the creation of a newly focused organization with a strengthened scientific knowledge base. These reforms helped NBS become a world leader in the field of fire research.

A second example of the contributions made through the peer review process is provided by the establishment in 1995 at the Army Research Laboratory (ARL) of an NRC board, the Technical Assessment Board, to review the quality of ARL programs. The first report made a number of recommendations, including reduction of what the panel called parochialism at ARL. Actions taken as a result of this review improved the laboratory's interactions with academia and industry. Such outside review often provides a different perspective that can be useful in shaping future work. The use of peer review, using experts in possession of varied and extensive experience, can much improve the quality of work and efficacy of results.

The Army Science and Technology Executive, Dr. Thomas Killion, requested a study of peer review methods in use at Army laboratories. This paper discusses Army laboratories in terms of generally accepted best practices and compares them with techniques at other DOD laboratories, and at a few other government agencies.

Background

Peer review of technical work is a well-established tradition in research and development. Review can be on individual projects or, more broadly, of a laboratory as a whole. There are three forms of project-focused review: one is used to evaluate proposals for new work, such as research proposals to funding agencies; a second is used to review work in progress, which is the primary focus of this study; and the third is used to review completed work in the form of reports or publications. In peer-reviewed journals, sometimes called archival journals, each paper is sent to technical experts for critique; changes may be suggested, or the paper may be rejected, based on lack of technical merit or originality.

While peer review has been used for many years in the Federal laboratories, there are no uniform standards or approaches. In a 1983 report to the White House Science Council, its Federal Laboratory Review Panel recommended that individual projects be subject to peer review at the outset. The panel also recommended the creation of, in its own words,

"an oversight function responsible for assuring the continuing excellence of the laboratory. This function could be performed by an external committee [and] would focus on productivity and on the excellence, relevance, and appropriateness of research."[1]

The report provided no details as to how the reviews should be performed. The President instructed the Office of Science and Technology Policy and the Office of Management and Budget to lead an interagency effort to respond to the Panel's recommendations. The results of this effort are documented in a 1984 report.[2] Various actions were undertaken; in particular, the DOD asked the Services to form external advisory groups.

Peer review was invented at the Royal Society in 1665 by the founding editor of Philosophical Transactions of the Royal Society, Henry Oldenburg. The present-day peer review system evolved from this 17th-century process."

A practice similar to a peer review process is found in *Ethics of the Physician*, written by Ishaq bin Ali al-Rahwi (854–931) of al-Raha, in what is now Syria. His work, as well as later Arabic medical manuals, state that a visiting physician must always make duplicate notes of a patient's condition on every visit. When the patient was cured or had died, the notes of the physician were examined by a local medical council of other physicians, who would review the practicing physician's notes to decide whether his/her performance have met the required standards of medical care. If their reviews were negative, the practicing physician could face a lawsuit from a maltreated patient. "

Peer review has been considered essential to the modern scientific method only since the middle of the 20th century. Before then, its application was frequently lax. For example, Albert Einstein's revolutionary "Annus Mirabilis" papers in the 1905 issue of *Annalen der Physik* were not reviewed by anyone other than the journal's editor in chief, Max Planck (the father of quantum theory), and its co-editor, Wilhelm Wien. Although clearly they were peers (both won Nobel prizes in physics), a formal panel of reviewers was not sought, as is done for many scientific journals today. Established authors and editors were given more latitude in their journalistic discretion at that time. As a recent editorial in *Nature* stated, "in journals in those days, the burden of proof was generally on the opponents rather than the proponents of new ideas."

Source: derived from Wikipedia entry on peer review, available at <http://en.wikipedia.org/wiki/peer_review>.

[1] Office of Science and Technology Policy, *Report of the White House Science Council Federal Laboratory Review Panel*, Recommendation 4-1 (Washington, DC: Executive Office of the President, 1983).
[2] Office of Science and Technology Policy, *Progress Report on Implementing the Recommendations of the White House Science Council's Federal Laboratory Review Panel* (Washington, D.C: Executive Office of the President, 1984).

Peer review tests the effectiveness of a laboratory's research staff by comparing the conduct of the laboratory's research with that at the best laboratories in the field. Outside experts compare the material under review with what they know of comparable work elsewhere—perhaps including their own work. External reviews reduce the tendency of a laboratory to become parochial, a special problem for laboratories that perform classified research. The expectation of scheduled peer reviews challenges the laboratory's technical staff to keep up with technical advances worldwide and to stay in touch with colleagues elsewhere. Peer review also brings varying perspectives on the work from laboratories across the Nation, or even around the world. Therefore, peer review is a way to establish a reputation for high-quality performance at a laboratory. For some portion of the assessment, review may be enhanced by the provision of data on performance against a number of metrics.[3]

Some Factors in Laboratory Quality

There are several factors in evaluating the quality of individual programs or groups of programs in a laboratory:

Status of the work. Planning, originality and creativity, publications and patents, comparison to work being done elsewhere, coordination or collaboration with others, and pacing or productivity are considered. The panel may also assess the program as a whole, e.g., the balance among basic, applied, and development research. Within these categories, reviewers may also consider the potential, or lack thereof, for beginning new areas of basic research.[4]

Qualifications of the research team. Reviews look at the record of accomplishments, awards and honors, and ability to present the work. First-rate equipment and modern facilities are essential for success—are they well supported? Is the overall budget adequate for the task? Finally, the working environment is important to an evaluation. Stimulating coworkers with technical prowess in their fields, and a supportive management team are important elements of productive laboratory work.

Relevance. This paper is not focused on relevance, though many of the reviews discussed herein address a mixture of quality and relevance. Factors in assessing relevance include: probability of success, priority of the need being addressed, validation of the need by the user, and collaborations with other laboratories. Relevance is also influenced by the timeliness of the delivery of results.

Credibility. For a review to have credibility across communities of interest, reviewers must be independent and impartial, able to comprehend technical details, and familiar with similar work being done elsewhere. Reviewers can be drawn from within the institution, if they are appropriately remote from the work, or from outside sources such

[3] Edward A. Brown, *Reinventing Government Research and Development: A Status Report on Management Initiatives and Reinvention Efforts at the Army Research Laboratory*, ARL-SR-57 (Adelphi, MD: Army Research Laboratory, August 1998).

[4] Hans Mark and Arnold Levine, *The Management of Research Institutions: A look at government laboratories*, NASA SP-481 (Washington, DC: NASA, 1984), 226.

as academia, industry, or other institutions. Any potential for bias or the perception of bias must be resolved.

Reporting. Review panels should make explicit reports, preferably in writing, to the head of the laboratory, and perhaps to higher levels of external management. The personnel reviewed should be given the results of the review. It is unusual to find a laboratory that cannot benefit from a thoughtful, professional critique. Such outside reviews should be sought by practitioners in any field. For laboratories, the review may take many forms. Some of these forms are investigated in this paper in terms of current practices at various Army, DOD, and other government laboratories.

Managing the Peer Review Process

The peer review process is generally strengthened by attention to the following concerns:

Review process. Two archetypal methods of establishing a reviewing system should be discussed. In the first, the laboratory under review may contract for the review with an outside party and only make recommendations to the contractor. In this model, the contractor manages the selection of panel members and provides logistical and operational support to the review panel. After finalizing the contract, the laboratory plays only a supporting role—offering suggestions, but otherwise maintaining a hands-off approach. In the contrary model, the laboratory selects panel members, defines review topics, and exercises close management control—a hands-on approach. The advantage of the hands-off approach is the enhanced credibility of the product. An advantage of the hands-on approach is that management is able to select panel members known to be particularly expert in the details of the programs under review.

Relationship of reviewers to reviewed. Another important factor is the relationship of the members of the review panel to the laboratory under review. To establish credibility, panel members should be seen as objective and independent of the laboratory. To this end, experts should be selected from outside the laboratory, and preferably outside the organizational parent of the laboratory. The use of panels selected from internal staff gives the appearance of favoring the laboratory's efforts out of loyalty and parochialism. Review panel members should include academics qualified to look at the basic research component. For applied research, members should be added from industry and other relevant laboratories. Possible conflicts of interest should be made known, and the panel constituted with appropriate balance to offset conflicts. Another benefit of external review is the injection of different experiences and points of view not available to in-house staff.

Quality and relevance. Quality is best judged by expert scientists and engineers active in the appropriate fields. Relevance is best judged by the users of the technical results, who may or may not know the technology in detail but have a technical appreciation of the need, and know whether the work adequately addresses that need. If the review is to address both technical quality and relevance, the membership of the panel will be mixed. One aspect of quality review is assessment of the laboratory environment—the suitability of the laboratory equipment and buildings, the characteristics of the staff, support groups,

such as the machine and electronic shops, the support and encouragement given by the senior managers of the laboratory, and the adequacy of the budget. To judge these aspects, the panel will necessarily need members who are researchers with experience at similar laboratories.

Following this general discussion of peer review, Chapter 2 presents the many ways the Army's S&T laboratories conduct reviews. Chapter 3 then discusses several approaches now being used at other Federal laboratories. Chapter 4 discusses the findings of this investigation. Chapter 5 provides closing comments and recommendations.

The paper recommends that the Army require peer review of the technical quality of its laboratories and proposes a set of norms that must be met. The principal recommendation is that reviews be performed by independent experts who visit the laboratory for two or more days, looking at the technical projects and the strength of the technical staff, equipment, and facilities. The recommendations include a caveat about potential conflicts of interest in these panels**.**

Chapter 2: Peer Review at Army Laboratories

To discover how the various Army laboratories carry out technical peer review of their work, interviews were conducted with leaders of each of the four segments of the Army that run research programs; namely, the Army Materiel Command's Research, Development, and Engineering Command (RDECOM) and its laboratories, the Medical Research and Materiel Command (MRMC), the Corps of Engineers (COE), and the Army Research Institute for the Behavioral and Social Sciences (ARI). For RDECOM, discussions were held with seven of the ten technical components—those that conduct bench-level research and development. Our investigation showed that the Army uses a variety of approaches to evaluate the performance of its research and development work. The following sections summarize the findings.

The Office of the Deputy Assistant Secretary of the Army (Research and Technology)

This office conducts many levels and kinds of reviews, two of which, done by its Director of Research and Laboratory Management (DRLM), are pertinent here. The first is the Basic Research Review; the other is the U.S. Army Research and Development Laboratory of the Year review. Both reviews use external panels of experts.

The DRLM appoints a set of independent review panels that review the Army's basic research (referred to as "6.1"), including in-house laboratory innovative research (ILIR). Rather than reviewing individual laboratories, the review considers broad technical areas that may include the work of more than one laboratory. The DRLM also appoints an external Army Science Assessment Group that reviews the findings of the independent review panels and makes comments and recommendations to the DRLM. This activity is performed every 3 years.

In the Army Laboratory of the Year competition, each laboratory makes a submission covering many different aspects of their work. One of these is a description of what they consider to be the single most significant accomplishment in fundamental research; another is a description of what they consider to be the single most significant accomplishment in development work. The DRLM appoints an Army Laboratory Assessment Group (ALAG), comprising external experts in relevant fields, to review and grade these submissions. The ALAG then sends a member to each of twelve laboratory installations for a day-long on-site review. Technical peer quality review of the research programs is only a small part of this program.

The Army Materiel Command's Research Development and Engineering Command

The Research, Development, and Engineering Command of the Army Materiel Command (AMC) manages the AMC laboratories, which consist of the Army Research Laboratory (ARL) and its Army Research Office (ARO), and six Research, Development and Engineering Centers (RDECs).

The Army Research Laboratory—ARL contracts with the National Research Council (NRC) of the National Academies to assemble an ARL Technical Assessment Board (TAB). The TAB consists of six panels, each composed of eight to ten individuals having high repute within the technical community. Each panel reviews one of ARL's primary technical mission areas. The Board, with its panels, provides an appraisal of the scientific and technical efforts of ARL. It is specifically enjoined from making judgments on the programmatic structure of ARL's work, partly because it is not equipped to perform this function, and partly because there are numerous other channels through which ARL receives such programmatic guidance. (Examples include: the normal chain of command above ARL, the Deputy Assistant Secretary of the Army for Research and Technology, the Director of Defense Research and Engineering, the Training and Doctrine Command, and the entire planning and budgeting process to include Congressional committees.)

Because of the size and diversity of the ARL technical program, the panels review the total program in depth over a 3-year period. There is a formal report from the TAB every 2 years. The panels produce a written assessment that is published by the NRC. The TAB also meets with the ARL director to provide an informal report of its findings before the publication of the report, and to receive guidance on the director's desires for special areas of emphasis for the subsequent year's review.

The AMC Research, Development and Engineering Centers—All of the RDECs work closely with acquisition program executive officers and program managers, and draw a considerable fraction of their support from these sponsors. RDECs have relatively little basic research funding; what little they have is from a special fund called Independent Laboratory Innovative Research (ILIR). Thus, peer review will emphasize the customer for the work, hence, relevance, timeliness, and quality.

None of the six AMC centers that conduct extensive in-house laboratory research conduct peer review of the kind described by ARL, but some are considering a similar approach. One uses a contractor to put together a panel to conduct biannual technical reviews for its 6.2 and 6.3 work (it has very little 6.1 money), and that work is reviewed in any case by the DRLM's Basic Research Review. Another RDEC began an external review in 2007 by contracting to obtain a panel of outside experts to review one major technical area of the RDEC for a given year; subsequently another panel will be set up to review another segment the following year.

Another RDEC is considering the introduction of formal technical reviews by external experts, but has not yet selected an approach. The remaining three RDECs are not using external technical peer review. It should be noted that all the AMC RDECs conduct extensive internal program reviews for RDECOM and frequent reviews with their customers.

Details of the interviews at the RDECs follow:

Aviation and Missile Research, Development, and Engineering Center—AMRDEC relies on two processes to review its programs. The technical quality is briefly looked at in the Army's Laboratory of the Year program. The panel of judges is composed of senior technologists external to the Army. They review AMRDEC's nomination package, and a panel member visits AMRDEC for a day. The AMRDEC program is also reviewed by a panel consisting primarily of retired general officers, with some representatives from senior S&T leadership. Panel members are chosen to have a diverse set of backgrounds to insure balance in their advice. This panel serves as a liaison for AMRDEC to the rest of the Army.

Armaments Research, Development, and Engineering Center—ARDEC uses a contractor to put together biannual technical peer reviews of 6.2 and 6.3 work. (The only basic research they have is the in-house laboratory innovative research (ILIR) funding). The panels are made up of technical specialists from across DOD, including some retirees from the uniformed Army. The panel members are paid for expenses and time, although some members will not accept remuneration. The panel receives briefings for 2–2 ½ days at the laboratory to assess quality and content, and spend additional time writing a report. The lab is reviewed this way every 2 years. The review uses a checklist designed to look at both individual program elements and the lab as a whole. The ARDEC presentations compare the work to other labs, such as Los Alamos or Livermore National Laboratories.

Natick Soldier Research, Development, and Engineering Center—NSRDEC brings in university academics to look at 6.1. NSRDEC has relied on the Army Science and Technology Working Group (ASTWG) process for additional review of outcomes and relevance, but does not carry out technical reviews. These reviews do not evaluate the quality of people, equipment etc. The Army Laboratory of the Year competition review sends an outside expert to NSRDEC for one day. This person obtains an overview and a tour of the laboratories. A technical peer review is not conducted.

The NSRDEC management is now ready to look at comprehensive peer review for 6.2 (and beyond) work. They want a methodology for looking at both quality and relevance. They want to evaluate technical quality, relevance, quality of individual skills, and the skill mix. They are also interested in benchmarking with other laboratories. They have had a prior process (described in a 2006 RDECOM report[5]), but discontinued that approach after judging it insufficient for peer review—it was more of an information sharing effort.

Edgewood Chemical Biological Center—The ECBC technical director first discussed the Army-wide laboratory of the year program, since the ALAG had just visited. The ALAG visitors impressed them, and ECBC in particular liked the on-site feedback they received from the visitors. The visit was for one day only; a second day would have provided time for more detailed presentations and visits to staff in their laboratories.

[5] RDECOM Committee, Chair Dr. J Mait, "*RDECOM Initiative on Peer Review and Benchmarking*", Final Report, September 2006. Available from Dr. J. Mait, Army Research Laboratory, Adelphi, MD.

ECBC believes the visit would have been more useful had it not been tied to a competition and ultimately an award to one laboratory. (The award process was felt to have limited the feedback to ECBC at the time of the visit, because some of the criticism would be used subsequently in the award decision.)

ECBC has used an eight-member focal group and facilitator to look at some of their programs. Members include retired generals and some technical people. They have looked at organizational issues such as the state of the facilities, and the technical merit of the work. They have provided a written report. ECBC has used IDA, RAND and the National Academies for studies focused on narrow areas of technology; for example, toxicity work at ECBC. The studies include visits to the labs. These are not intended to be comprehensive and should not be construed as related to an overall peer review process.

Communications and Electronics Research, Development, and Engineering Center— CERDEC does not have a technical peer review process in the sense used in this paper. CERDEC relies solely on the laboratory of the year ALAG visits for external assessment. However, a former technical director had earlier invited groups of "graybeards" to the laboratory periodically to review the technical work. This process was unstructured, informal, and eventually discontinued.

In regard to the process for the Army Laboratory of the Year, CERDEC offered some criticisms. CERDEC claims not to receive formal feedback for two months or more after the visit. The funds allocated by DRLM for the ALAG visits evidently will not allow for visits to both Ft Monmouth and Ft Belvoir, so the ALAG is able to visit only part of the RDEC each year.

This year, the ALAG visitor had a security clearance and was able to go into the classified facility and receive detailed briefings not available to previous ALAG visitors. CERDEC believes the ALAG visits are too short and too limited as to the amount of information that can be provided. They also find that statements made by the visitors during the visits do not always agree with the formal feedback received much later. They believe, with ECBC and NSRDC, that the ALAG process would be better without limiting the competition for an award to just one laboratory. They believe that a longer visit, say two or more days, using a panel of experts would improve the process by allowing more in-depth discussion and more visits to laboratories.

Tank and Automotive Research, Development, and Engineering Center—TARDEC uses senior technical personnel, including two STs (senior technical positions without administrative duties and equivalent to positions in the Senior Executive Service) for internal technical reviews. On a quarterly basis they do full program reviews. They also do an internal technical peer review before starting new programs. The internal reviews also include work done by Small Business Innovation Research (SBIR) program grants and all Congressional add-ons.

TARDEC has begun outside peer review by contracting with the Institute for Defense Analysis (IDA) to select a panel of outside experts. The first review was in 2007 and was

on survivability technology. They plan to continue these reviews; next up are power and energy technologies. The expert panels have five to ten members who meet in 3-day workshops. This process reviews just one topical area each year; TARDEC has found this to be a very effective way to evaluate technical quality.

The technical director believes that the laboratory of the year program does not meet the criteria of a peer review process for technical work. The technical director expressed interest in the National Research Council review program.

Medical Research and Materiel Command—All of the MRMC's R&D is externally reviewed under a contract managed by the American Institute of Biological Sciences (AIBS), formerly a part of the National Academies and now independent. Review is done using panels consisting of distinguished external experts who possess the appropriate subject matter expertise. These reviews are for research proposals made to MRMC. Intramural researchers must also make annual proposals for their work; these too are reviewed by AIBS panels. The research program at MRMC is divided into four program elements, each of which is overseen by a program manager at headquarters. Every 3–5 years, each program element brings in a review panel to look at both quality and program content. Most reviews are conducted by AIBS; on occasion reviews are obtained through the National Academies' Institute of Medicine or the National Research Council. The quality of facilities and equipment are only sporadically reviewed; comments on facilities and equipment are sometimes offered by panel members during site visits.

Engineer Research and Development Center—The Army Corps of Engineers' ERDC consists of seven laboratories at four sites. Each laboratory is reviewed every 2 years by external panels of about ten experts. The ERDC director manages the selection of experts and the meeting agendas. The panels review quality of work, staff, equipment, and facilities. The panels also look at program relevance. The panels provide a qualitative ranking comparing the ERDEC programs to the best peer laboratories around the world. The reviews usually last 3 days. Written reports are submitted, usually within a month after the meetings. The panels review technical programs in detail and visit the laboratory staff at the bench level. Panel members are nominated by each of the seven laboratory directors and approved by the ERDC director. The members are paid for their time. There is some dual membership across the panels. Members are from industry and retired military and include several members of the National Academies. Some are eminent in their respective fields; some are generalists. There is a standard protocol for the labs to follow in conducting their biannual reviews.

Army Research Institute for the Behavioral and Social Sciences—ARI has 124 authorized positions and a budget of $32M. About half of the budget is spent outside the Institute on contracts or grants. Last year the 6.1 budget was doubled to $6.0 million, thereby allowing ARI to broaden and deepen its research. ARI operates its own office to solicit, evaluate, and allocate research grants. The ARI has no laboratories in the usual sense. Instead it has staff distributed across many different Army Training and Doctrine Command (TRADOC) centers and schools.

ARI sometimes has joined with ARL's Human Research and Engineering Directorate for research reviews of focused areas. ARI believes that quality can be measured by success in transition and adoption, by the Army, of their recommendations. This is not, however, a technical peer review.

ARI has the NRC Board on Behavioral, Cognitive, and Sensory Sciences study possible new areas for work every 3–4 years. For external scientific reviews, ARI uses advisory groups that include both internal and external panel members. There is a formal panel on leader development, a small TRADOC panel on training, and a mixed military/science panel on personnel. The ARI staff who work in a given area of technology attend these reviews and receive instant feedback. The advice is usually verbal and not in written reports.

Chapter 3: Peer Review at Some Other Government Laboratories

At this point it is useful to review approaches to peer review used at other DOD laboratories and at laboratories at other Federal agencies, either owned and operated by the government or contracted by the government to private entities. It should be noted that, as was the case with the Army laboratories, peer review is done in several different ways at these other laboratories. One type of review is that done by the National Academies' National Research Council (NRC). The NRC has study boards for all three Services. The Boards may perform in-depth technical reviews. The Defense Science Board (DSB) has reviewed the Defense laboratories, but not in terms of specific technical work. Rather, the DSB has looked at DOD's policies for the laboratories—a higher level of review. One aspect of external review is that the Federal Advisory Committee Act (FACA) may govern the operation. This means that meetings must be public, members of the public may make presentations to the committee, and members are appointed only with concurrence of the President's agents (typically the General Services Administration or agency heads). These requirements would have infringed on the traditional operations of the National Academies. After consideration, the FACA was amended to exempt the Academies from many of the requirements.

The Services have traditionally convened their own advisory committees to look at technology issues, e.g., the Army Science Board, the Air Force Science Advisory Board, the Naval Studies Board, and the Naval Research Advisory Committee. These groups differ in their operations. Some are involved in detailed technical studies, others restrict themselves to policy studies. All of them come under the FACA. On occasion, ad hoc advisory committees may be set up, often by direction of the U.S. Congress. Two examples are the Federal advisory commission established to review the Services' plans for realigning their laboratories during the base realignment and closure activity for 1991,[6] and a committee chartered by the Congress to study the future relevance of DOD laboratories.[7] A series of reports on visits by the latter committee to several DOD laboratories was issued in 2002.[8] These reports were the result of one-time reviews, after which the committee in question ceased to exist. Congressional committees, the Government Accountability Office, and even the Library of Congress have also done policy studies of the laboratories.

[6] Federal Advisory Commission on Consolidation and Conversion of Defense Research and Development Laboratories, *Report to the Secretary of Defense* (Washington, DC: Department of Defense, September 1991).

[7] National Defense Authorization Act of FY 2000, S-1059, 106th Congress, Section 913.

[8] National Defense University, *Section 913 Report #1, #2, #3*, (Washington, DC: Center for Technology and National Security Policy, 2002). Copies of this report are available from the Office of the Director, Center for Technology and National Security Policy, National Defense University.

Assessment of the Laboratories at the National Institute of Standards and Technology

The programs at the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards (NBS), have been assessed by the National Academies' National Research Council (NRC) since the 1950s. This was among the first regularly recurring quality reviews of a Federal laboratory by the NRC, and it continues to this day. (Recently the review has been emulated at the Army Research Laboratory. See discussion of ARL in chapter 2.)

Peer review by the NRC began at NBS after a prolonged controversy over NBS' evaluation of a commercial product. After these issues were settled in NBS' favor, the Secretary of Commerce asked the National Academy of Science (now the National Academies) the parent of the NRC, to study various aspects of NBS activities. One result was the establishment of a separate NRC board to assess on a regular basis the quality of NBS work and the factors affecting that work. A set of evaluation panels was created under the NRC Board on Assessment for the National Bureau of Standards (now the NRC Committee on NIST Technical Programs). These panels met once a year (more recently every other year), generally for 2 days, to review technical work, visit the laboratories, view buildings and equipment, and talk with staff. They provided a written report vetted by the NRC and published to the general public. Typically there were (and are) separate panels for each major operating unit at NBS.

The panels occasionally look at cross-cutting research that spans more than one division. On occasion, the NIST director requests attention to certain areas, e.g., quality of support services, state of buildings and working laboratory spaces, and status—age, morale, and so on—of technical staff.

From the outset, the panels were made up of experts drawn mostly from outside the Federal government. Members may be nominated by anyone, but the selections are controlled by the NRC. Panel members are not paid, except for travel expenses. (A firm NRC policy holds that none of its committee members should receive remuneration.) The assessment work is scheduled and managed by NRC staff dedicated to the purpose. Reports are published by the National Academies Press and are not restricted.

The individual panels are overseen by the NRC Committee on NIST Technical Programs. The chairman of the committee often has joined in discussions with the NIST statutory visiting committee about NIST, both in presentations to the visiting committee and in presenting findings to the Secretary of Commerce and the NIST authorization committees in Congress.

Other Approaches

Interviews with senior officials at a number of Federal laboratories have revealed several different models for peer review. Some are formal review panels that come under the FACA; others are formal but managed internally by the Service or the laboratory. An example of one managed by a Service is the review by the Air Force Scientific Advisory Board (SAB).

The Air Force Research Laboratory—The SAB, a formal Federal Advisory Committee, was set up shortly after World War II by General Henry ("Hap") Arnold and headed by Dr. Theodore von Karman. At first known as the Scientific Advisory Group, it prepared a landmark series of reports known collectively as "Toward New Horizons."[9] This work focused on the then state-of-the-art and outlined detailed plans for research in the sciences and technologies deemed critical to the future of air power. The group reported directly to Gen. Arnold. Today, as the SAB, it continues to report to the Air Force Chief of Staff and the Secretary of the Air Force. Among other duties, the SAB reviews in depth the scientific work of the Air Force Research Laboratory (AFRL) on a 2-year cycle. The review covers both the 6.1-6.3 work but also work sponsored by downstream users, such as program managers or executive officers. One panel has been created for each AFRL directorate. Panel members are selected by the SAB; all are external to the Air Force. Most are members of the SAB, but when necessary the SAB brings in consultants. At least one member of each panel must be a member of the National Academies.

The SAB conducts reviews of each directorate, devoting a full week to each. The panels provide an exit briefing and a formal report. The reports are sometimes made available to the public, but some may be restricted (FOUO, for official use only). The panels look at four factors for the programs: technical, relevance for the near term (5 yrs), future impacts, and resources. When evaluating the 6.1 programs, the SAB does not look at near-term impacts. For the technical work (factor 1), SAB evaluates technical innovation, technical rigor, productivity, and collaboration.

The Naval Research Laboratory—Two external groups have been established to look at various technical topics for the Navy: the NRC's Naval Studies Board, and the Naval Research Advisory Committee, created by the Chief of Naval Operations. Both groups consider the impact of technical developments on the future of naval forces. For detailed technical review of its technical base research programs, the Naval Research Laboratory (NRL) establishes and manages its own peer review. NRL has seven focus areas: materials and chemistry, electronics, battlespace environment, underseas warfare, electromagnetic warfare, space research/space technology, and information technology.

Technical review of the technical base covers about one-third of the total research program each year. NRL selects members for the external review panels for each focus area. A panel typically has four to six members drawn from academia and elsewhere, along with at least one member of the National Academies. The NRL asserts that these members are unbiased. The panels meet for from two to four days with time for immersion in the labs and staff. The panels give exit briefings to the NRL management. Subsequently, they submit a formal written report of about 10-15 pages, and NRL responds to this in writing.

[9] Michael H. Gorn (editor), *Prophecy Fulfilled, 'Toward New Horizons' and its Legacy* (Washington, DC: Air Force Historical Studies Office, 1994). Available at <http://www.airforcehistory.hq.af.mil/Publications/authorindex.htm/>

The panels evaluate the programs for scientific merit: they examine the research approach, the credentials of the staff, the project's relevance, equipment, and costs. Details of these differ for 6.1 and 6.2. For 6.1, the panels look for work that seeks to expand the frontiers of known science; for 6.2 the panels look for whether NRL is investigating and developing recent advances in science and technology. They have seven categories of evaluation containing metrics. For the customer-funded work, the criteria used are those of the customers.

The National Institutes of Health—The NIH operates peer review by nineteen formal advisory committees, termed boards of scientific counselors, one for each of the institutes. Their duties are described as follows: "Boards of Scientific Counselors serve a dual function in providing expert scientific advice to Scientific Directors regarding particular employees and projects, and providing the NIH as a whole with an assessment of the overall quality of its intramural efforts."[10]

There is a Committee Management Office at NIH to track these and many other NIH advisory committees. The office stays in contact with the FACA Office of the General Services Administration. The NIH process is the most formal type of quality review discovered in interviews for this study.

Three National Laboratories of the Department of Energy—Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and Sandia National Laboratory (SNL) are government-owned, contractor-operated facilities under the Department of Energy (DOE). Interviews at these three laboratories revealed very similar processes for peer review. The Department of Energy National Nuclear Security Administration (NNSA) contracts for LANL and LLNL explicitly call for regular peer review; Sandia's contract contains similar language. LANL and LLNL are operated by a consortium of the University of California and the Bechtel Corporation, with additional partners from the Babcock and Wilcox Company and the Washington International Group. Two limited liability corporations have been created to manage the contracts: the Los Alamos National Security LLC, and the Lawrence Livermore National Security LLC. There is a joint Board of Governors for the two LLCs. The Board has a Subcommittee on Science and Technology (the S&T Committee) that oversees and controls peer reviews of S&T at both laboratories. The S&T Committee makes the appointments to the peer review panels upon nomination by the laboratories. The panels are independent and balanced. Each does both review and critique. The panels have eight to ten members drawn from academia (about half), industry, and other labs; there are some University of California faculty, and some from other National Laboratories. The operation of the panels does not come under the FACA.

Los Alamos National Laboratory conducts three kinds of review. The first review is strictly concerned with quality of scientific activity and is focused on capability areas rather than on scientific disciplines. Typically, these are crosscuts from the discipline

[10] Directory of NIH Federal Advisory Committees and HHS Advisory Committees Managed by NIH Staff, (Washington, D.C.: National Institutes of Health, January 2008), 6. Available at <www1.od.nih.gov/cmo/committees/directoryofnihadvisorycommittees>.

areas, such as weapons science and information science. They cover eight capabilities per year; each capability area is reviewed every 3 years. The review panels meet for 3–4 days. (In earlier times these reviews were run strictly in-house and covered only scientific disciplines, not capabilities.) The panels also look at the adequacy of the lab infrastructure, the morale of the staff, and the research environment. The other reviews are on weapons design and customer programs. The design reviews are done internally by DOE weapons design teams; the customer reviews look at quality, relevance, and performance against the mission. Customer reviews are set up by the laboratory subject to approval by the Board of Governors' S&T Committee.

Lawrence Livermore National Laboratory follows a similar assessment process. At LLNL, there are four principal disciplines and three major program areas. All are reviewed by peer panels. In addition, they conduct cross-cutting reviews of portfolios (for example, the National Ignition Facility) involving more than one of the seven areas. The panels consist of 10–15 members drawn from academia, industry, and other laboratories. Members are selected by the LLNL directorates and vetted by the Board of Governors' S&T Committee. Selection factors include diversity on the panels and turnover of membership. The panels usually have a member from LANL and someone from NNSA. Panel reports contain both critique and advice. Verbal exit briefings are given to the head of the unit under review, as well as to senior managers and the LLNL director. Reports of the panels are circulated within DOE but are restricted.

Sandia National Laboratory is operated under a contract between NNSA and Sandia Corporation, a wholly owned subsidiary of the Lockheed Martin Corporation. There are six Lockheed employees on the Sandia Corporation Board of Directors. The Corporation's S&T Committee is chaired by the Chief Technical Officer of Lockheed. About half of the $2 billion plus budget at Sandia National Laboratory is S&T.

Peer review at Sandia is divided between S&T and nuclear weapons work. For S&T, the reviews are conducted under contract to the University of Texas (UT), which has two positions on the Board of Sandia Corporation. Under supervision by the Sandia Corporation Board of Directors Subcommittee on S&T, UT selects and convenes review panels. Both Sandia management and Sandia Corporation have input into the final selections.

Each panel has 6–12 members from various disciplines, including physical sciences, computation, electronics, and materials. UT draws some panel members from its faculty; other members are drawn from wherever they can find qualified individuals. There is an external panel for each competence. Panels meet for multi-day sessions and cover individual projects/programs. The panels meet with staff members to assess morale and the research environment. They also may meet with groups of principal investigators at the program level, as well as with individual project leaders. The review results are reported to laboratory management and the Board of Directors' S&T Committee. Principal Investigators receive the reports and must respond to panel critiques.

Nuclear weapons-related peer review at Sandia includes three kinds of internal reviews: design, management, and internal peer review (members from entities other than the design team under review). Reviews are assisted by a full-time office of assessment that reports directly to the laboratory director. The assessment staff is internal but separate from the program areas. There is also a standing panel for external independent review of these Sandia assessments. These assessments are a critical part of the regular certification of America's nuclear weapons stockpile.

Peer review at grant-making organizations

Entities that award grants—for example, the National Science Foundation (NSF), the Army Research Office (ARO), the Office of Naval Research (ONR), and the Air Force Office of Scientific Research (AFOSR)—do not operate laboratories and, therefore, conduct quality reviews in a different manner. NSF is overseen by the National Science Board that reports to the Congress. Each NSF directorate is monitored by a formal advisory committee that meets regularly to review performance. Periodically, members of the committee review the grant folders to ensure that procedures have been followed. Grant proposals are sent out to experts for evaluation; subsequently the folders are evaluated by NSF staff before the decision to award or not to award is made. For work in progress, grantees are visited on site by NSF program managers. Quality is judged by these reviews, regular reports, and copies of publications. The ultimate test of how well a grantee is doing is the renewal or termination of the grant. This is true for all the granting agencies.

ARO conducts two kinds of peer review concerning single investigator (SI) proposals for new work. One review evaluates technical merit. Typically the proposal is sent to external reviewers, mostly university faculty. The other review focuses on military relevance and is done by Army and DOD scientists and engineers. The SI grants are typically for 3 years. Two or more site visits are usually conducted during this time. Program managers will audit grantees presentations at scientific meetings and gauge audience reaction. ARO receives formal annual reports and copies of all publications by its grantees.

The ARO divisions are evaluated biennially by external boards of visitors, one for each division. The boards look at the overall portfolios, evaluating the strategic direction of the divisions and looking out for overlap with other programs in the DOD or elsewhere.

AFOSR, a directorate within AFRL, manages the 6.1 funds for the Air Force. Funding executed by AFRL internal research directorates is evaluated by the SAB during the biennial reviews of those directorates. The AFOSR as a whole is reviewed by the SAB every 2 years.

Office of the Secretary of Defense

The Director of Defense Research and Engineering for a number of years conducted Technology Area Reviews and Assessments (TARA) reviews that covered DOD basic research programs. Representatives of the Service laboratories and operating commands

participated in these reviews, along with outside experts. TARA reviews are no longer conducted.

Clearly there is no single, accepted best way to conduct peer review of Federal S&T laboratories. Chapter 4 summarizes the results of the preceding investigation into the peer review process. Recommendations are presented in chapter 5.

Chapter 4: A Summary of Peer Review Practices

There are almost as many approaches to peer review as there are laboratories contacted for this study. Laboratory practices range from practically no review to formal reviews conducted under the Federal Advisory Committee Act. The following discussion presents the range of practices uncovered in interviews and literature study. This is followed by consideration of the pros and cons of the several approaches. Chapter 5 offers a set of performance guidelines for the Army.

Most of the laboratories studied have some kind of peer review. At one end of the spectrum stands NIH, which has an external advisory committee for each of its institutes. These committees operate in the public eye under the FACA. NIH review processes operate under a very formal arrangement. AFRL has a formal arrangement with the Air Force Science Advisory Board (SAB), operated from the offices of the Chief of Staff and the Secretary of the Air Force. Thus, the SAB is once removed from the laboratory. The SAB also takes its authority from the FACA. Another formal process is the use of dedicated boards and committees of the NRC, under contract with the laboratories.

Several laboratories manage their own review processes, some of which are subject to oversight by a higher level of management. The DOE weapons laboratories are reviewed by expert panels, whose nominations from laboratory management are subject to approval by the contractor that operates the laboratory. Some of the Army laboratories contract out at least a portion of the process. Laboratory directors generally value outside review, but emphasize that the reviewers must be experts in the specific sciences and technologies being studied at their laboratories. In cases where the technologies are highly specialized, there may be only a small external community from which to draw reviewers. Furthermore, these may be somehow involved in the laboratory's research, making conflict of interest a problem. (NSF and the NRC address this issue not by disqualifying an otherwise desirable expert, but rather by making the potential conflict known and balancing the various interests that may exist on their panels.)

Some experts are drawn from universities or industry, while some come from within the Army or other government laboratories. Several Army laboratories use exclusively external review panels. Most of the others have some external and some internal members. No evidence was found of unresolved conflicts of interest.

The scope of the peer reviews varies. Some reviews are strictly limited to the quality of the research, and to assessment of the quality of the staff and facilities. Other reviews address a mixture of quality and relevance, while still others appear limited to questions of relevance. Typically, the quality-oriented reviews employ many academics who specialize in the subjects of interest. The relevance assessments are carried out by customers, such as program executive officers and program managers; or representatives of soldiers, such as senior Army officers from the Training and Doctrine Command.

Most of the Army's technical peer reviews are aimed at evaluating individual project areas. A few look more broadly at the laboratory's overall efforts. ARL's TAB looks at all the technical work, both S&T-funded and customer work; the Air Force's SAB similarly looks at all the AFRL work. An important question is whether or not the review extends beyond the technical work itself to broader questions, such as the status of staff, equipment, facilities, and the work environment. These judgments would require that the panels make extensive visits to the laboratories, talk to staff, and generally familiarize themselves with the environment. .

Most of the panels under consideration here prepare formal written reports in addition to the informal feedback provided during the reviews. The reports are sent to managers and are available to the research staff. In some cases they are available to the public. The reports prepared for the DOE weapons laboratories are marked FOUO. In some laboratories, local managers are required to report back the actions taken in response to recommendations made by the panels.

Chapter 5: Closing Comments & Recommendations

It is unlikely that any one model of peer review will suffice for the Army laboratories. The authors believe, however, that some form of independent external review of technical quality is necessary for every Army laboratory. The Army should require that these reviews be undertaken, even if differing in some details from laboratory to laboratory.

A model that focuses on quality review of the technical work will apply well to laboratories that perform a large amount of basic and applied research (6.1 and 6.2). However, if a laboratory has a large component of advanced development work and beyond, this work too should be included in the review. In such cases, the panel experts will include technically trained individuals representing both customers and users. Some of the development and engineering centers will likely want to devote relatively more effort to issues of project relevance to the armed forces. A center that has little 6.1 research will probably count on the DRLM basic research reviews. However, all the technical work, whether in the S&T program or in customer-sponsored work, should be reviewed for quality. This can be combined with other types of reviews, or evaluated separately.

Table 1 contains a list of questions relevant to the design of the peer review process; answers to these questions should be useful for comparing and contrasting practices at various laboratories.

Table 1: Important Questions to Consider in Peer Review

Is there any peer review at all?
Who manages the review?
Are external experts used in the review?
Are the experts independent and free of conflicts of interest?
Are the experts external to the project staff, or external to the laboratory?
Are the experts external to the Army?
Does the review focus on issues of quality, relevance, or both?
Does the review focus on individual projects, or on the laboratory as a whole?
Does the review consider the quality of staff, equipment, facilities, or the working environment?
Are explicit, formal reports produced?

A uniform Army definition of the term *external review* should be established. A distinction should also be made in Army terminology between quality peer review and relevance review. Whether these reviews should be done separately or in combination is an open question that may be answered differently in different laboratories. Similarly, the expertise required of reviewers will vary. External review panels should be balanced between the requirements of expertise and "distance," from the reviewed parties (to avoid damaging conflicts of interest). Contracting with an outside entity, such as the NRC or some other independent contractor, to convene review panels and manage the process will enhance the credibility of the results. Alternatively, reviews could be managed by an entirely separate internal organization, as is done in the DRLM Basic Research Reviews. (The BRR is a hybrid approach wherein the panels are external experts but the naming of members and convening of the panels are directed by the DRLM. The important point is that credibility is enhanced by independent reviews.

The scope of reviews should cover individual projects in enough detail that quality of the work is exposed. If a single panel is used for an entire laboratory, the sampling of projects and presenters will be less likely to give a reliable picture than if multiple panels are used, each focusing on a particular set of disciplines or programs. A trade-off must be made between cost and the depth of the reviews.

To evaluate not only the specific projects that are presented but also to assess the research environment—staff, management, equipment, and facilities—a panel will need to spend 2–3 days at the laboratory to allow walking around, talking to staff, and getting a feel for the ambience of the laboratory. Simply sitting in a conference room will only give an impression of the projects selected for review, and little else.

Review panels should provide informal feedback to the management and staff at the time of the review, but should also submit a formal written report. This report should be provided to interested parties within the laboratory and to managers up the chain of command. Internal and external organizations charged with oversight of the laboratory should receive the reports. Part of the process should be to require the laboratory to respond to panel recommendations at the next review.

Recommendations

The following recommendations are offered as the basis for a directive from the Deputy Assistant Secretary of the Army for Research and Technology (DAS(RT)) to laboratory managers. Since there is unlikely to be a single mode of review, the recommended approach is to establish guidelines that will set a minimum performance bar that is to be met or exceeded by all Army S&T laboratories.

The DAS(RT) should, in consultation with laboratory management, issue a written policy on peer review covering all Army S&T laboratories. The policy should be accompanied by detailed guidance along the lines of the following recommendations:

Recommendation 1. *The policy should require the laboratories to empower outside groups to convene peer review panels and manage the review process.* The policy should

point out the enhanced credibility of panels that are so convened. These arrangements will normally be created through the use of contracts. The reputation of the contractor should be an important factor in the selection process. Specific steps should be taken to ensure that conflict of interest on the part of the proposed experts is dealt with either by disqualifying the candidate or, in the case of very small pools of available experts, making the potential conflict known in advance and achieving balance by selection of the other members. Laboratory managers may suggest panel members but should not control the appointments. Membership will vary, depending on whether the laboratory elects to have separate reviews for quality and relevance or consolidated reviews.

Recommendation 2. *The policy should require that the reviews themselves be done by panels of experts external to, and independent of, the laboratory.* For review of technical quality, the panels should consist of researchers in the same fields drawn from academia, industry, research institutes, and other government laboratories. For review of relevance, the panels should have both technical experts and representatives of the user, such as program executive officers and program managers and the TRADOC. Retired Army officers can be of help in both quality and relevance reviews.

Recommendation 3. *Reviews should be done every 2 or 3 years.* To spread out the burden of handling the reviews, the annual review process should be staggered such that any one area is only reviewed every 2 or 3 years.

Recommendation 4. *The reviews should cover technical details at the project level.* Enough time should be allowed for the panel to hear many different project presentations, selected to give a true picture of the laboratory's work. One way to provide good coverage of the laboratory programs is to have separate panels for each major segment of the laboratory program. The panels should be allowed to spend 2 or more days in review.

Recommendation 5. *The panels should also assess the quality of the staff, the management environment, the equipment, and the facilities.* This can be done by encouraging panel members to walk through the laboratory and to talk to staff.

Recommendation 6. *The panels should provide feedback to the laboratory staff and prepare formal written reports.* Reports should be submitted to the laboratory management, and copies provided to relevant members of the chain of command. Copies of the reports should be filed in the DAS(RT) office. The laboratories should be required to respond to panel recommendations or critiques at the next meeting.

If this set of recommendations is adopted and executed, the result should be improved quality of the Army's technical work, enhanced reputation of the laboratories, and strengthened support of the laboratories among the Army's senior leaders, as well as within the Administration and in Congress.

Appendix A: Interviewees

The following individuals were interviewed for this report:

- Air Force
  - Air Force Research Laboratory—Michael Kuliasha, Chief Technologist

- Navy
  - Naval Research Laboratory—John Montgomery, Technical Director

- Army
  - Army Materiel Command
    - Research, Development, and Engineering Command—Gary Martin, Deputy to the Commanding General
      - Aviation and Missile RDEC—William McCorkle, Technical Director
      - Armaments RDEC—Joe Lannon, Technical Director
      - Army Research Laboratory—Joe Mait, ST
      - Army Research Office—Dave Skatrud, Director
      - Communications and Electronics RDEC—Art Ballato, ST (with Geo. Oliva)
      - Edgewood Chemical and Biological Center—Rick Decker, Technical Director
      - Natick Soldier RDEC—Marilyn Freeman, Technical Director
      - Tank and Automotive RDEC—Grace Bocheneck, Technical Director
  - Army Research Institute of the Behavioral and Social Sciences—Michelle Sams, Director
  - Engineering Research and Development Center—James Houston, Director
  - Medical Research and Materiel Command—Frasier Glenn, Principal Assistant to the Commanding General for Research and Development

- Department of Energy
  - Lawrence Livermore National Laboratory—Lee Younker, Director, Operations and Assessment
  - Los Alamos National Laboratory—Terry Wallace, Principal Deputy Director for Science
  - Sandia National Laboratory—Joan Woodard, Deputy Laboratory Director for Nuclear Weapons (with Gary Sanders)